Airborne Lidar Report

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OH Chippewa Watershed Lidar 2017 B17

Contract Number: G16PC00022
Task Number: G17PD00344

Contractor: Woolpert, Inc.
Woolpert Project # 77548

September 2017

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Section 1: Overview

TASK ORDER NAME: OH Chippewa Watershed Lidar 2017 B17

Project: # 75926

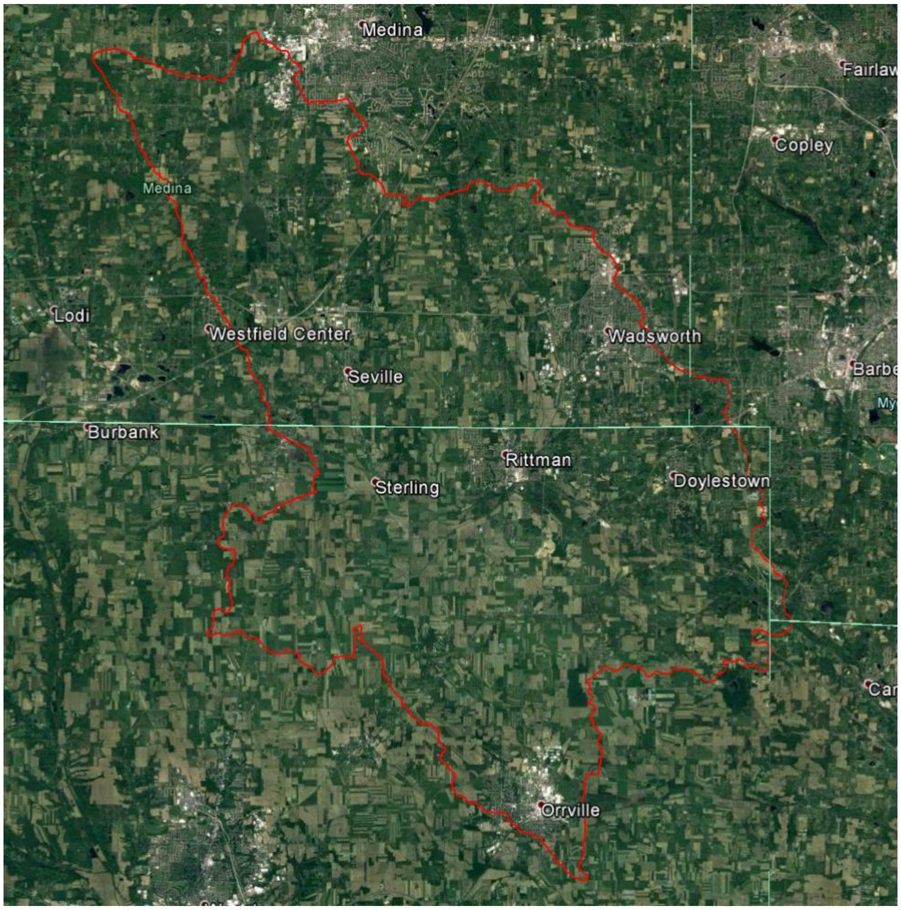
This report contains a comprehensive outline of the OH Chippewa Watershed Lidar 2017 B17 Lidar task order. Processing task order for the United States Geological Survey (USGS). This task is issued under USGS Contract No. G16PC00022, Task Order No. G17PD000344 This task order requires lidar data to be acquired over approximately 188 square miles of northeast Ohio of V.1.2 lidar, for the area of interest (AOI) collected at a nominal pulse spacing (NPS) of 0.7 meters. The NPS assessment is made against single swath, first return data located within the geometrically usable center portion (typically ~90%) of each swath.

The data was collected using three Leica ALS80 HP 1000 kHz Multiple Pulses in Air (MPiA) lidar systems on board Woolpert aircraft. The ALS80 sensor collects up to four returns per pulse, as well as intensity data, for the first three returns. If a fourth return was captured, the system does not record an associated intensity value. The aerial lidar was collected at the following sensor specifications:

Table 1.1: ALS80 Specifications – Woolpert	
Post Spacing	0.70 m
AGL (Above Ground Level) average flying height	2,377 m
Average Ground Speed:	150 knots
Field of View (full)	40 degrees
Pulse Rate	346 kHz
Scan Rate	35.5 Hz
Side Lap	26%

The horizontal datum used for the task order was referenced to NAD83(HARN) State Plane Ohio U.S. Feet. The vertical datum used for the task order was referenced to NAVD 1988, U.S. Feet, GEOID12B.

Figure 1.1: OH Chippewa Watershed Lidar 2017 B17 Task Order AOI



Section 2: Acquisition

The lidar data was acquired with three Leica ALS80HP 1000 kHz Multiple Pulses in Air (MPiA) Lidar Sensor Systems. The ALS80 HP lidar system, developed by Leica Geosystems of Heerbrugg, Switzerland, includes the simultaneous first, intermediate and last pulse data capture module, the extended altitude range module, and the target signal intensity capture module.

The ALS80HP 1000 kHz Multiple Pulses in Air (MPiA) Lidar System has the following specifications:

Table 2.1: ALS80 HP Lidar System Specifications	
Operating Altitude	100 – 7,620 meters
Scan Angle	0 to 72° (variable)
Swath Width	0 to 1.5 X altitude (variable)
Scan Frequency	0 – 200 Hz (variable based on scan angle)
Maximum Pulse Rate	1000 kHz (Effective)
Range Resolution	Better than 1 cm
Elevation Accuracy	6 - 19 cm single shot (one standard deviation)
Horizontal Accuracy	5 – 43 cm (one standard deviation)
Number of Returns per Pulse	Unlimited
Number of Intensities	3 (first, second, third)
Intensity Digitization	8 bit intensity + 8 bit AGC (Automatic Gain Control) level
MPiA (Multiple Pulses in Air)	8 bits @ 1nsec interval @ 50kHz
Laser Beam Divergence	0.22 mrad @ $1/e^2$ (~0.15 mrad @ 1/e)
Laser Classification	Class IV laser product (FDA CFR 21)
Eye Safe Range	400m single shot depending on laser repetition rate
Roll Stabilization	Automatic adaptive, range = 75 degrees minus current FOV
Power Requirements	28 VDC @ 25A
Operating Temperature	0-40°C
Humidity	0-95% non-condensing
Supported GNSS Receivers	Ashtech Z12, Trimble 7400, Novatel Millenium

Prior to mobilizing to the project site, flight crews coordinated with the necessary Air Traffic Control personnel to ensure airspace access.

Crews were onsite, operating a Global Navigation Satellite System (GNSS) Base Station for the airborne GPS support.

The Lidar data was collected in one (1) mission. An initial quality control process was performed immediately on the Lidar data to review the data coverage, airborne GPS data, and trajectory solution. Collection of lidar data took place on March 23, 2017.

Figure 2.1: Lidar Flight Layout, OH Chippewa Watershed Lidar 2017 B17

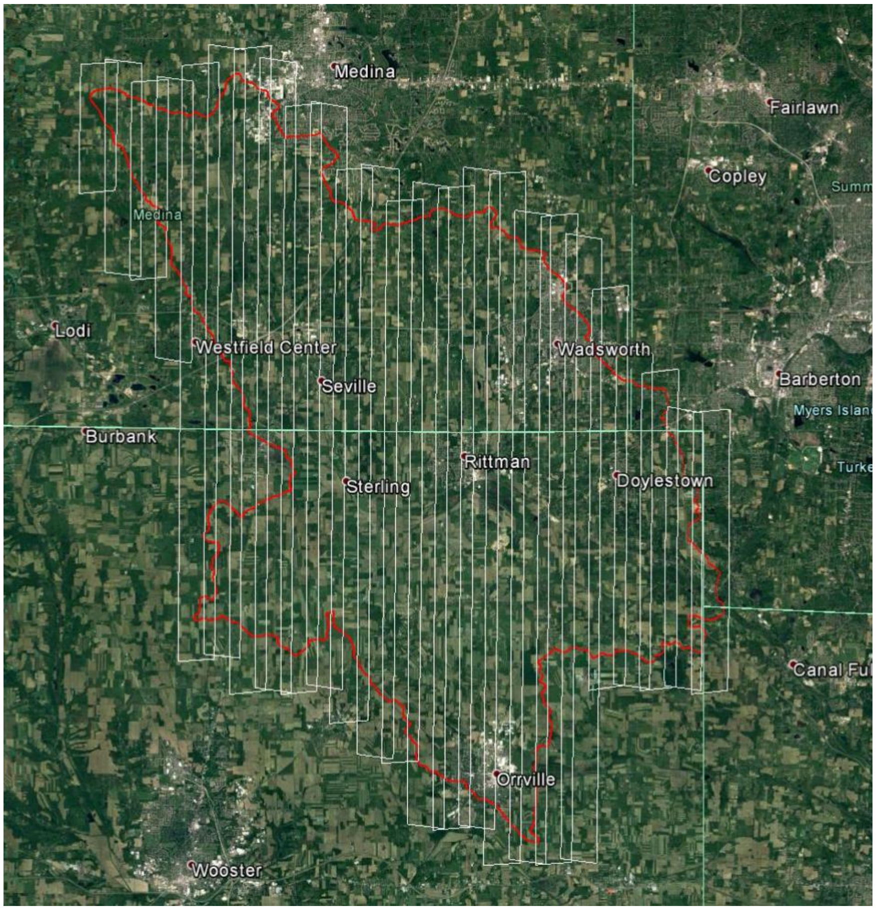


Table 2.3: Airborne Lidar Acquisition Flight Summary		
Date of Mission	Lines Flown	Mission Time (UTC) Wheels Up/ Wheels Down
March 23, 2017_SH8191	**1-25**	**17:19 – 20:39**

Section 3: LiDAR Data Processing

Applications and Work Flow Overview

1. Resolved kinematic corrections for three subsystems: inertial measurement unit (IMU), sensor orientation information and airborne GPS data. Developed a blending post-processed aircraft position with attitude data using Kalman filtering technology or the smoothed best estimate trajectory (SBET).
Software: POSPac Software v. 5.3, IPAS Pro v.1.35., Novatel Inertial Explorer v8.60.6129
2. Calculated laser point position by associating the SBET position to each laser point return time, scan angle, intensity, etc. Created raw laser point cloud data for the entire survey in LAS format. Automated line-to-line calibrations were then performed for system attitude parameters (pitch, roll, heading), mirror flex (scale) and GPS/IMU drift.
Software: ALS Post Processing Software v.2.75 build #25, Proprietary Software, TerraMatch v.17.01., Add Leica Cloud Pro v1.2.3
3. Imported processed LAS point cloud data into the task order tiles. Resulting data were classified as ground and non-ground points with additional filters created to meet the task order classification specifications. Statistical absolute accuracy was assessed via direct comparisons of ground classified points to ground RTK survey data. Based on the statistical analysis, the lidar data was then adjusted to reduce the vertical bias when compared to the survey ground control.
Software: TerraScan v.17.01.
4. The LAS files were evaluated through a series of manual QA/QC steps to eliminate remaining artifacts from the ground class.
Software: TerraScan v.17.01.

Global Navigation Satellite System (GNSS)–Inertial Measurement Unit (IMU) Trajectory Processing

Equipment

The pilots are skilled at maintaining their planned trajectory, while holding the aircraft steady and level. If atmospheric conditions are such that the trajectory, ground speed, roll, pitch and/or heading cannot be properly maintained, the mission is aborted until suitable conditions occur.

Base stations were set by acquisition staff and were used to support the Lidar data acquisition. The GNSS base station operated during the Lidar acquisition missions is listed below:

Table 3.1: GNSS Base Station

Station (Name)	Latitude (DMS)	Longitude (DMS)	Ellipsoid Height (L1 Phase center) (Meters)
NGS_PID_KY3557	40°52'28.69962"	81°52'55.01731"	309.697

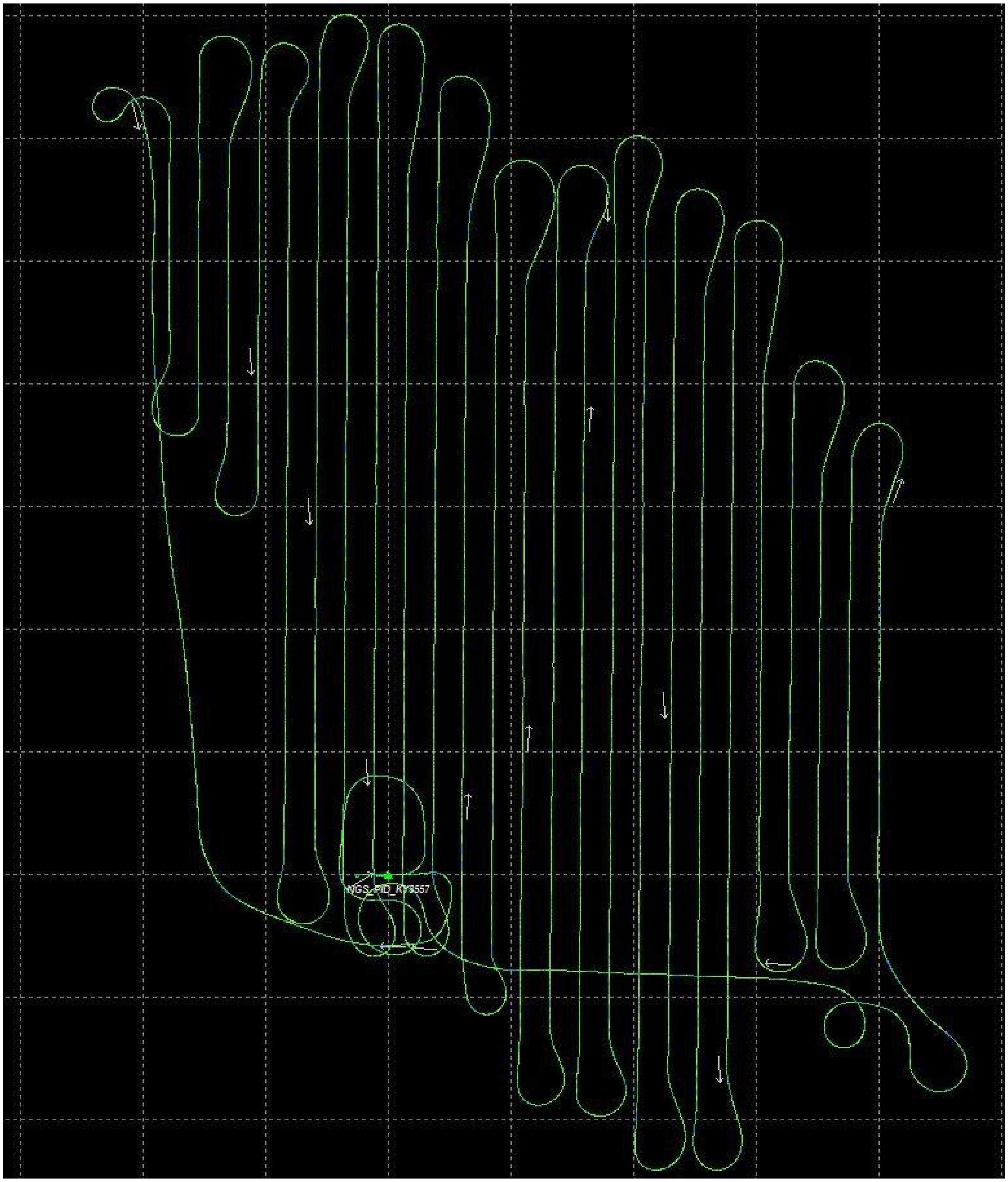
Data Processing

All airborne GNSS and IMU data was post-processed and quality controlled using Applanix MMS software. GNSS data was processed at a 1 and 2 Hz data capture rate and the IMU data was processed at 200 Hz.

Trajectory Quality

The GNSS Trajectory, along with high quality IMU data are key factors in determining the overall positional accuracy of the final sensor data. Within the trajectory processing, there are many factors that affect the overall quality, but the most indicative are the combined separation, the estimated positional accuracy, and the Positional Dilution of Precision (PDOP).

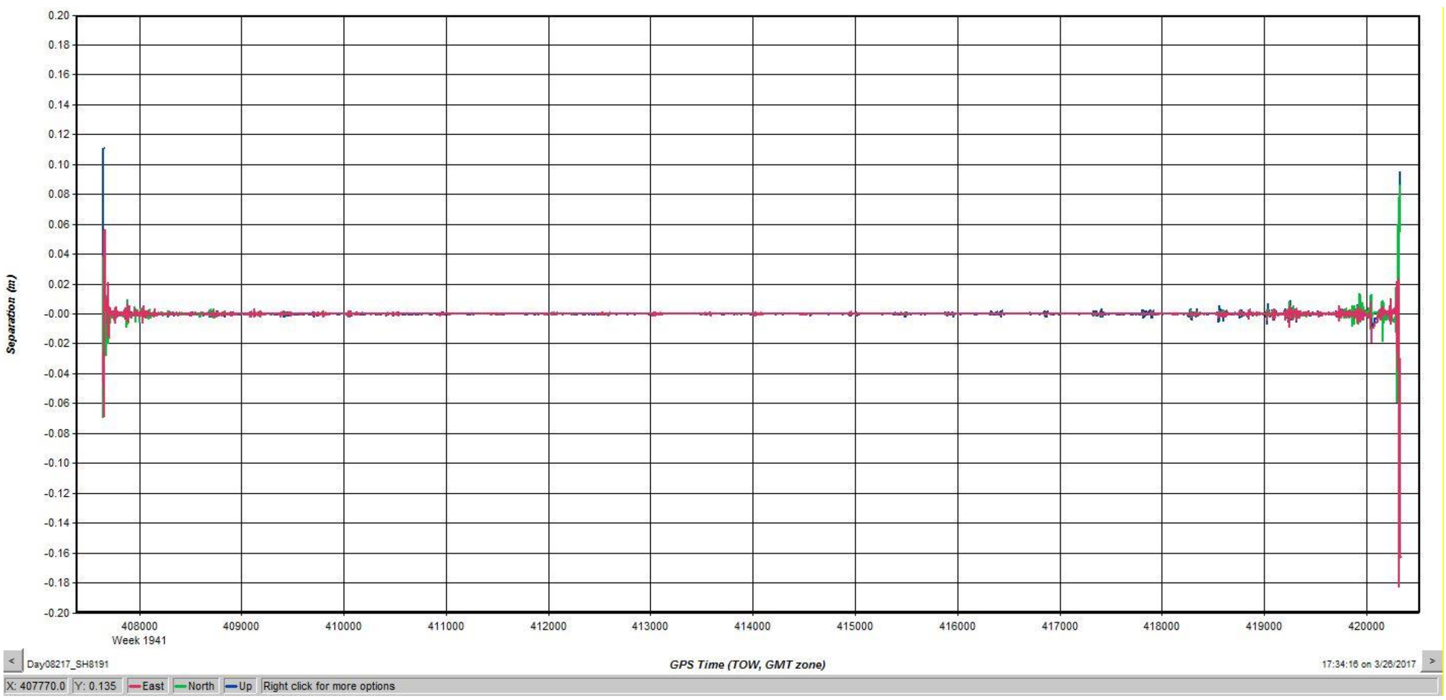
Figure 3.1: Trajectory, Day08217_SH8191



Combination Separation

The Combined Separation is a measure of the difference between the forward run and the backward run solution of the trajectory. The Kalman filter is processed in both directions to remove the combined directional anomalies. In general, when these two solutions match closely, an optimally accurate reliable solution is achieved.
Woolpert's goal is to maintain a Combined Separation Difference of less than ten (10) centimeters. In most cases we achieve results below this threshold.

Figure 3.2: Combined Separation, Day08217_SH8191

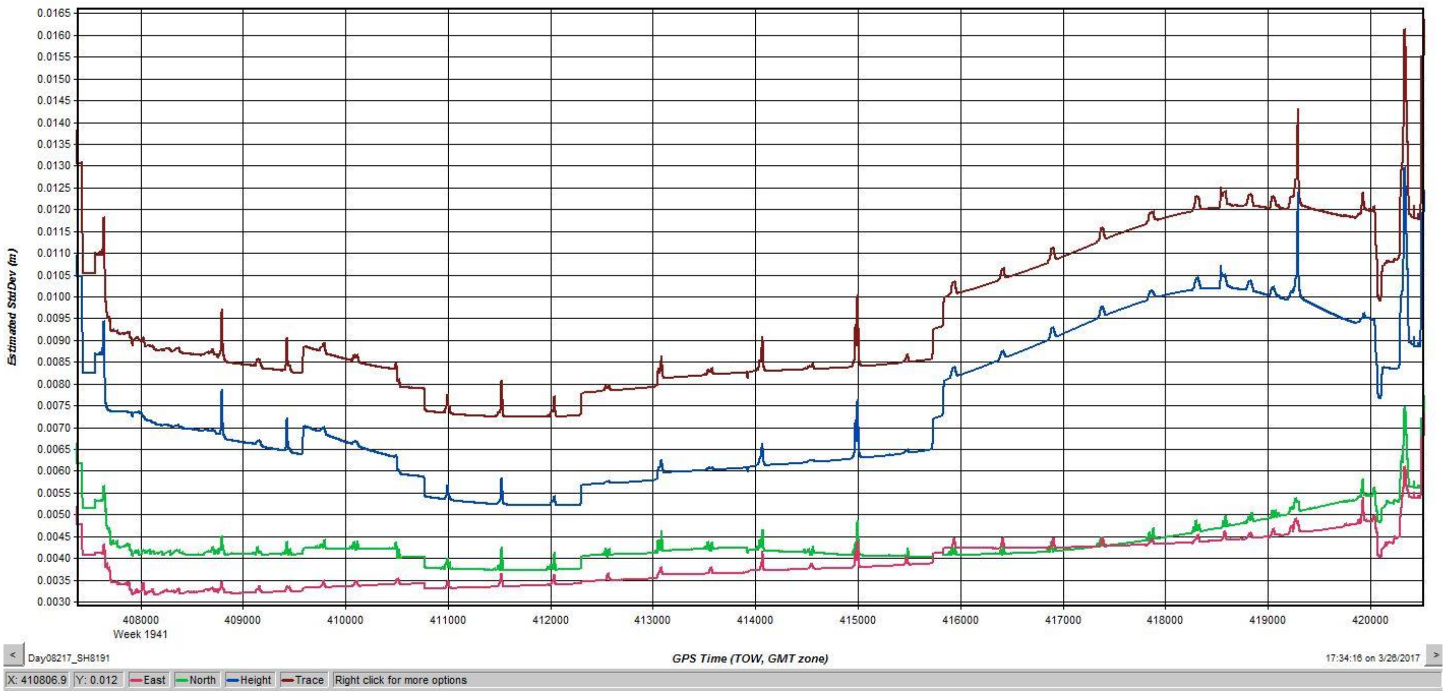


Estimated Positional Accuracy

The Estimated Positional Accuracy plots the standard deviations of the east, north, and vertical directions along a time scale of the trajectory. It illustrates loss of satellite lock issues, as well as issues arising from long baselines, noise, and/or other atmospheric interference.

Woolpert's goal is to maintain an Estimated Positional Accuracy of less than ten (10) centimeters, often achieving results well below this threshold.

Figure 3.3: Estimated Positional Accuracy, Day08217_SH8191

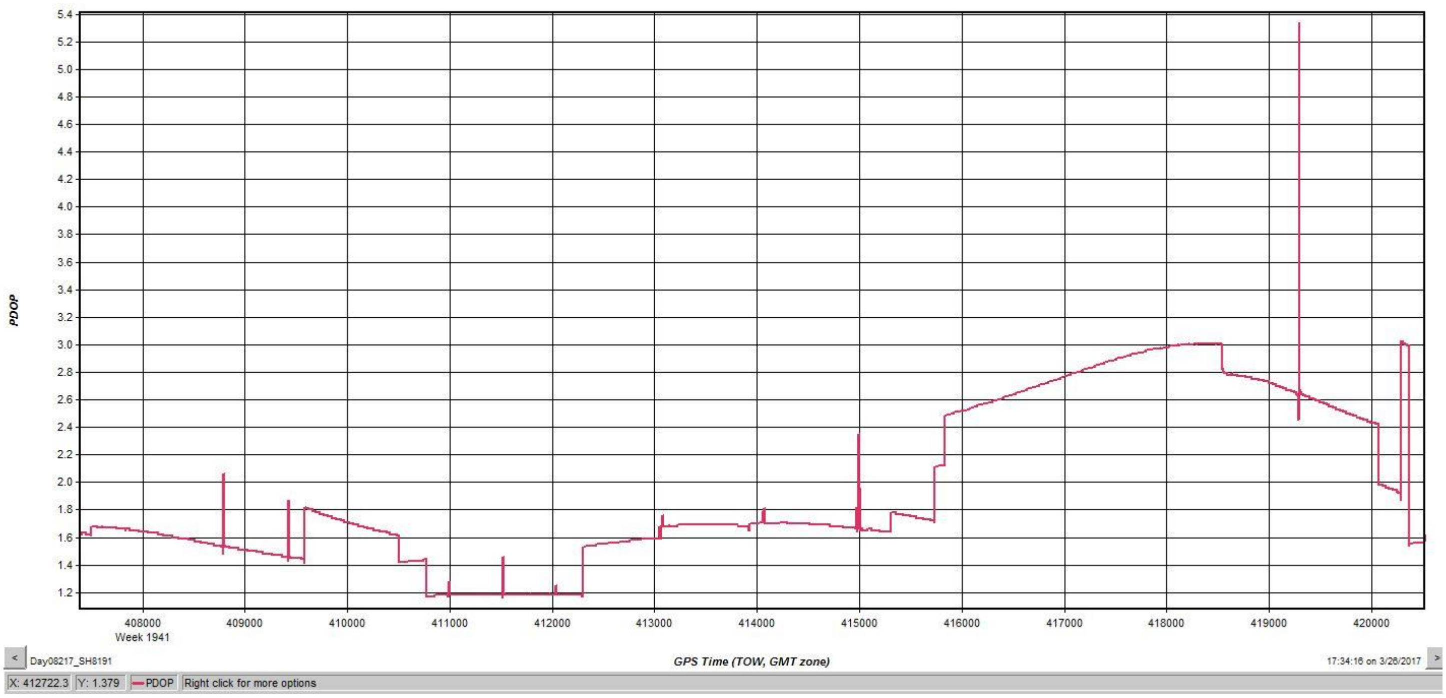


PDOP

The PDOP measures the precision of the GPS solution in regards to the geometry of the satellites acquired and used for the solution.

Woolpert's goal is to maintain an average PDOP value below 3.0. Brief periods of PDOP over 3.0 are acceptable due to the calibration and control process if other metrics are within specification.

Figure 3.4: PDOP, Day08217_SH8191



LiDAR Data Processing

When the sensor calibration, data acquisition, and GPS processing phases were complete, the formal data reduction processes by Woolpert lidar specialists included:

- Processed individual flight lines to derive a raw “Point Cloud” LAS file. Matched overlapping flight lines, generated statistics for evaluation comparisons, and made the necessary adjustments to remove any residual systematic error.
- Calibrated LAS files were imported into the task order tiles and initially filtered to create a ground and non-ground class. Then additional classes were filtered as necessary to meet client specified classes.
- Once all project data was imported and classified, survey ground control data was imported and calculated for an accuracy assessment. As a QC measure, Woolpert has developed a routine to generate accuracy statistical reports by comparisons against the TIN and the DEM using surveyed ground control of higher accuracy. The lidar is adjusted accordingly to meet or exceed the vertical accuracy requirements.
- The lidar tiles were reviewed using a series of proprietary QA/QC procedures to ensure it fulfills the task order requirements. A portion of this requires a manual step to ensure anomalies have been removed from the ground class.
- The lidar LAS files are classified into the Processed but not classified (Class 1), Bare earth ground (Class 2), Low Noise (Class 7), Water (Class 9), Ignored ground (Class10), Bridge Decks (Class 17), High Noise (Class 18) classifications.
- FGDC Compliant metadata was developed for the task order in .xml format per product.
- The horizontal datum used for the task order was referenced to NAD83 (HARN) Ohio State Plane North Zone, U.S. Feet. The vertical datum used for the task order was referenced to NAVD 1988, U.S. Feet, GEOID12B

Section 4: Hydrologic Flattening

HYDROLOGIC FLATTENING OF LIDAR DEM DATA

OH Chippewa Watershed Lidar 2017 B17 processing task order required the compilation of breaklines defining water bodies and rivers. The breaklines were used to perform the hydrologic flattening of water bodies, and gradient hydrologic flattening of double line streams and rivers. Lakes, reservoirs and ponds, at a minimum size of 2-acre or greater, were compiled as closed polygons. The closed water bodies were collected at a constant elevation. Rivers and streams, at a nominal minimum width of 30 meters (100 feet), were compiled in the direction of flow with both sides of the stream maintaining an equal gradient elevation.

LIDAR DATA REVIEW AND PROCESSING

Woolpert utilized the following steps to hydrologically flatten the water bodies and for gradient hydrologic flattening of the double line streams within the existing lidar data.

1. Woolpert used the newly acquired lidar data to manually draw the hydrologic features in a 2D environment using the lidar intensity and bare earth surface. Open Source imagery was used as reference when necessary.
2. Woolpert utilizes an integrated software approach to combine the lidar data and 2D breaklines. This process "drapes" the 2D breaklines onto the 3D lidar surface model to assign an elevation. A monotonic process is performed to ensure the streams are consistently flowing in a gradient manner. A secondary step within the program verifies an equally matching elevation of both stream edges. The breaklines that characterize the closed water bodies are draped onto the 3D lidar surface and assigned a constant elevation at or just below ground elevation.
3. The lakes, reservoirs and ponds, at a minimum size of 2-acre or greater and streams at a minimum size of 30 meters (100 feet) nominal width, were compiled to meet task order requirements. **Figure 4.1** illustrates an example of 30 meters (100 feet) nominal streams identified and defined with hydrologic breaklines. The breaklines defining rivers and streams, at a nominal minimum width of 30 meters (100 feet), were draped with both sides of the stream maintaining an equal gradient elevation.
4. All ground points were reclassified from inside the hydrologic feature polygons to water, class nine (9).
5. All ground points were reclassified from within a buffer along the hydrologic feature breaklines to buffered ground, class ten (10).
6. The lidar ground points and hydrologic feature breaklines were used to generate a new digital elevation model (DEM).

Figure 4.1: Example Hydrologic Breaklines

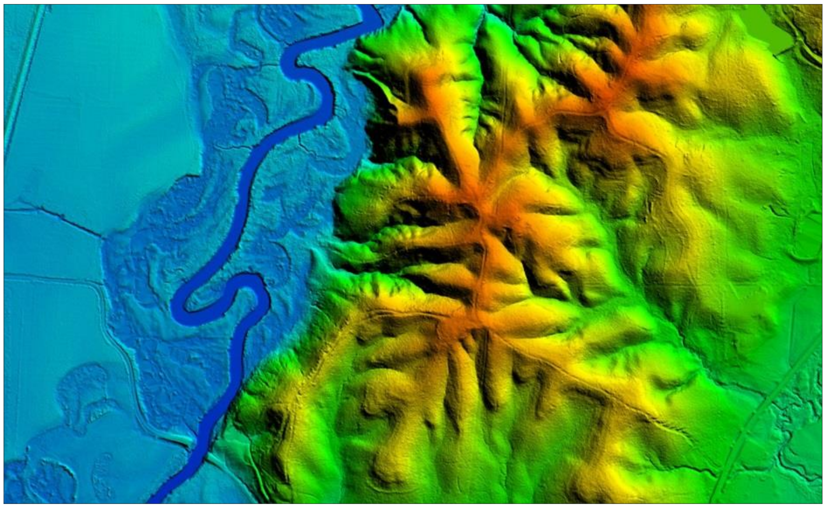


Figure 4.2 reflects a DEM generated from original lidar bare earth point data prior to the hydrologic flattening process. Note the "tinning" across the lake surface.

Figure 4.3 reflects a DEM generated from lidar with breaklines compiled to define the hydrologic features. This figure illustrates the results of adding the breaklines to hydrologically flatten the DEM data. Note the smooth appearance of the lake surface in the DEM.

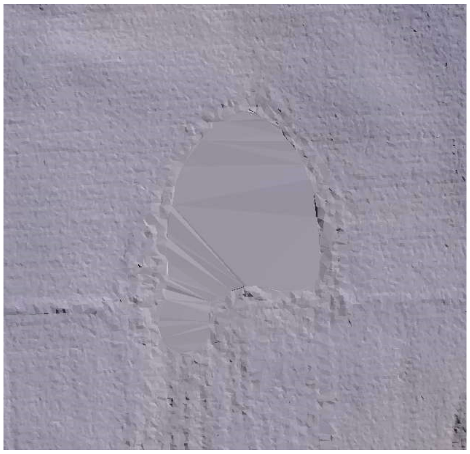


Figure 4.2

Figure 4.3

Terrascan was used to add the hydrologic breakline vertices and export the lattice models. The hydrologically flattened DEM data was provided to USGS in ERDAS .IMG format.

The hydrologic breaklines compiled as part of the flattening process were provided to the USGS in ESRI shapefile format. The breaklines defining the water bodies greater than 2-acre and for the gradient flattening of all rivers and streams at a nominal minimum width of 30 meters (100 feet) were provided in geodatabase as a Polygon-Z and Polyline-Z shape file, respectively.

DATA QA/QC

Initial QA/QC for this task order was performed in Global Mapper v17, by reviewing the grids and hydrologic breakline features. Additionally, ESRI software and proprietary methods were used to review the overall connectivity of the hydrologic breaklines.

Edits and corrections were addressed individually by tile. If a water body breakline needed to be adjusted to improve the flattening of the DEM data, the area was cross referenced by tile number, corrected accordingly, a new DEM file was regenerated and reviewed.

Section 5: ACCURACY ASSESSMENT

Accuracy Assessment

The vertical accuracy statistics were calculated by comparison of all lidar points to the ground surveyed QC points.

Table 5.1: Overall Vertical Accuracy Statistics		
Average error	+0.028	US Sv Feet
Minimum error	-0.100	US Sv Feet
Maximum error	+0.280	US Sv Feet
Average magnitude	0.077	US Sv Feet
Root mean square	0.100	US Sv Feet
Standard deviation	0.098	US Sv Feet

Table 5.2: RAW Swath Quality Check Point Analysis NVA

Point ID	Easting (US Sv Feet)	Northing (US Sv Feet)	Elevation (US Sv Feet)	TIN Elevation (US Sv Feet)	Dz (US Sv Feet)
2001	2124766.520	522128.460	1034.600	1034.730	0.130
2002	2161834.450	507318.050	1009.360	1009.340	-0.020
2003	2178462.810	495289.940	1133.570	1133.590	0.020
2004	2189804.040	475523.510	1257.500	1257.430	-0.070
2005	2177308.920	466607.990	964.390	964.350	-0.040
2006	2178716.380	450528.190	1109.290	1109.300	0.010
2007	2172027.160	429419.890	1061.360	1061.510	0.150
2008	2148640.920	474759.970	968.240	968.310	0.070
2009	2161102.280	476974.630	1110.680	1110.810	0.130
2010	2137006.660	482974.590	991.810	991.930	0.120
2011	2133225.980	510848.870	1006.620	1006.590	-0.030
2012	2131637.980	455838.130	1145.790	1145.810	0.020
2013	2159033.120	456004.690	1037.430	1037.470	0.040
2014	2145209.080	524993.750	1207.470	1207.470	0.000
2015	2112506.690	532573.350	1130.850	1131.130	0.280
2016	2153582.780	443193.350	1173.900	1173.860	-0.040
2017	2200379.510	453916.130	1128.760	1128.670	-0.090
2018	2155685.990	501952.990	1212.540	1212.470	-0.070
2019	2126510.560	500128.380	1164.870	1164.990	0.120
2020	2166912.470	489135.380	1144.750	1144.940	0.190
2021	2150291.620	514258.270	1234.460	1234.440	-0.020

2022	2142495.800	496251.810	1008.120	1008.080	-0.040
2023	2130950.020	535834.480	1101.880	1101.780	-0.100
2024	2123108.590	511487.710	1131.200	1131.240	0.040
2025	2201192.600	468716.410	1168.270	1168.180	-0.090

VERTICAL ACCURACY CONCLUSIONS

Raw Swath Non-Vegetated Vertical Accuracy (NVA) Tested 0.059 meters Non vegetated vertical accuracy at a 95 percent confidence level, derived according to NSSDA, in open terrain using (RMSEz) x 1.96000 as defined by the National Standards for Spatial Data Accuracy (NSSDA); assessed and reported against 25 NVA points using National Digital Elevation Program (NDEP)/ASPRS Guidelines and tested against the TIN using all points.

LAS Swath Non-Vegetated Vertical Accuracy (NVA) Tested 0.058 meters Non vegetated vertical accuracy at a 95 percent confidence level, derived according to NSSDA, in open terrain using (RMSEz) x 1.96000 as defined by the National Standards for Spatial Data Accuracy (NSSDA); assessed and reported against 25 NVA points using National Digital Elevation Program (NDEP)/ASPRS Guidelines and tested against the TIN using ground points.

Table 5.3: NVA Check Point Analysis DEM

Point ID	Easting (US Sv Feet)	Northing (US Sv Feet)	Elevation (US Sv Feet)	DEM Elevation (US Sv Feet)	Dz (US Sv Feet)
2001	2124766.520	522128.460	1034.600	1034.732	-0.132
2002	2161834.450	507318.050	1009.360	1009.342	0.018
2003	2178462.810	495289.940	1133.570	1133.632	-0.062
2004	2189804.040	475523.510	1257.500	1257.423	0.077
2005	2177308.920	466607.990	964.390	964.392	-0.002
2006	2178716.380	450528.190	1109.290	1109.292	-0.002
2007	2172027.160	429419.890	1061.360	1061.452	-0.092
2008	2148640.920	474759.970	968.240	968.252	-0.012
2009	2161102.280	476974.630	1110.680	1110.792	-0.112
2010	2137006.660	482974.590	991.810	991.922	-0.112
2011	2133225.980	510848.870	1006.620	1006.592	0.028
2012	2131637.980	455838.130	1145.790	1145.852	-0.062
2013	2159033.120	456004.690	1037.430	1037.492	-0.062
2014	2145209.080	524993.750	1207.470	1207.462	0.008
2015	2112506.690	532573.350	1130.850	1131.152	-0.302
2016	2153582.780	443193.350	1173.900	1173.822	0.078
2017	2200379.510	453916.130	1128.760	1128.612	0.148
2018	2155685.990	501952.990	1212.540	1212.432	0.108
2019	2126510.560	500128.380	1164.870	1165.002	-0.132

2020	2166912.470	489135.380	1144.750	1144.912	-0.162
2021	2150291.620	514258.270	1234.460	1234.502	-0.042
2022	2142495.800	496251.810	1008.120	1008.082	0.038
2023	2130950.020	535834.480	1101.880	1101.762	0.118
2024	2123108.590	511487.710	1131.200	1131.192	0.008
2025	2201192.600	468716.410	1168.270	1168.122	0.148

VERTICAL ACCURACY CONCLUSIONS

Bare-Earth DEM Non-Vegetated Vertical Accuracy (NVA) Tested 0.062 Meters Non-Vegetated vertical accuracy at a 95 percent confidence level, derived according to NSSDA, in open terrain using (RMSEz) x 1.96000 as defined by the National Standards for Spatial Data Accuracy (NSSDA); assessed and reported against 25 NVA points using National Digital Elevation Program (NDEP)/ASPRS Guidelines and tested against the DEM.

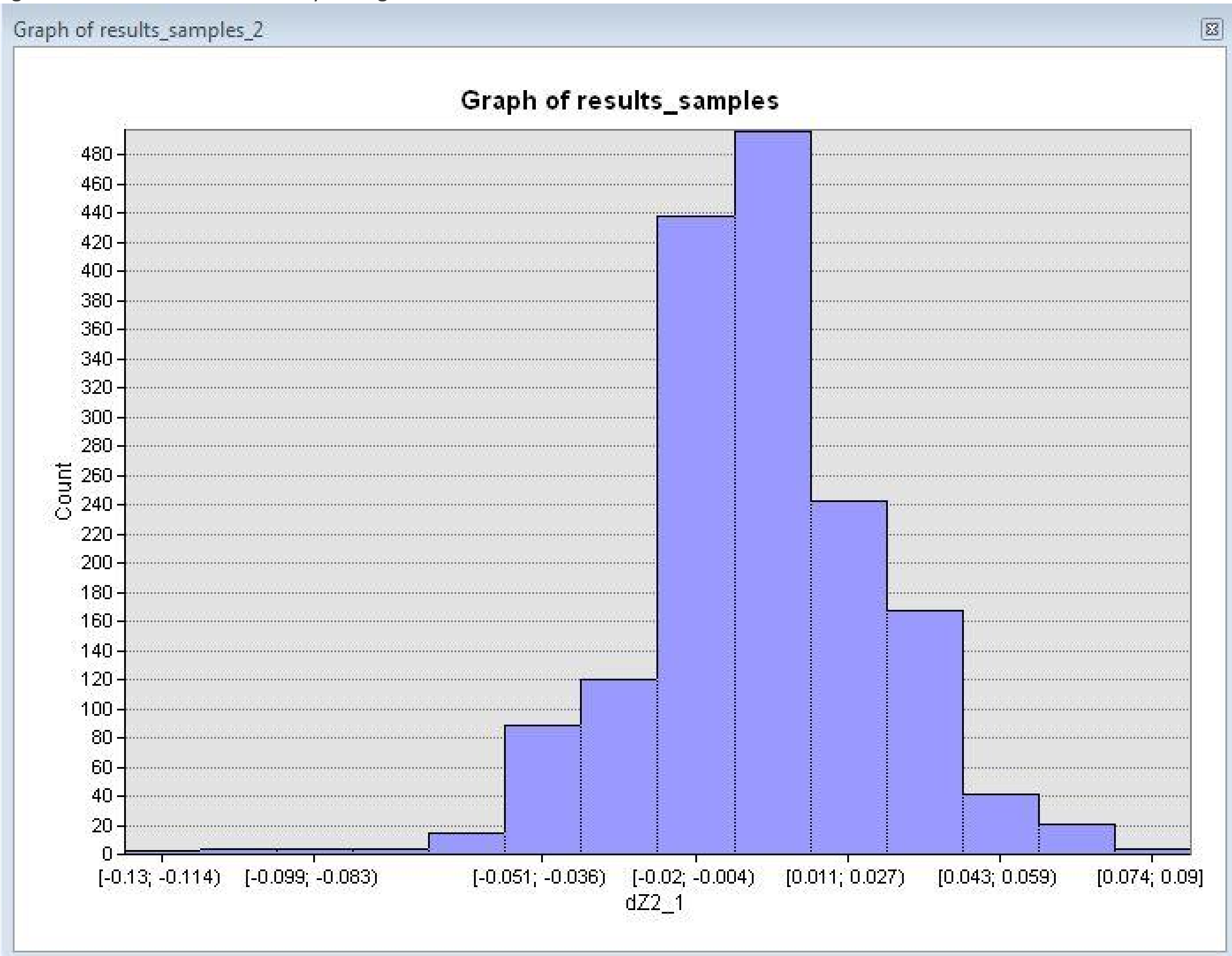
Table 5.4: VVA Quality Check Point Analysis DEM

Point ID	Easting (US Sv Feet)	Northing (US Sv Feet)	Elevation (US Sv Feet)	DEM Elevation (US Sv Feet)	Dz (US Sv Feet)
3001	2112995.230	533246.640	1137.920	1137.842	0.078
3002	2175587.690	502312.510	1171.380	1171.722	-0.342
3003	2199809.340	453944.670	1116.860	1117.072	-0.212
3004	2147105.410	475998.880	971.500	972.082	-0.582
3005	2135079.960	497933.720	991.740	992.412	-0.672
3006	2133291.630	530128.960	1093.330	1093.472	-0.142
3007	2175867.960	429848.320	1012.110	1012.912	-0.802
3008	2144008.090	455926.310	1135.760	1136.492	-0.732

VERTICAL ACCURACY CONCLUSIONS

Vegetated Vertical Accuracy (VVA) Tested 0.236 meters at the 95th percentile reported using National Digital Elevation Program (NDEP)/ASPRS Guidelines and tested against the DEM using 8 VVA points. VVA Errors larger than 95th percentile include:
Point 3007, Easting 2175867.960, Northing 429848.320, Z-Error 0.244 meters

Figure 5.1: Lidar Relative Accuracy Histogram



RELATIVE ACCURACY ASSESSMENT AND CONCLUSION

Relative accuracy also known as "between swath" accuracy was tested through a series of well distributed flight line overlap locations. The relative accuracy for the OH Chippewa Watershed Lidar 2017 B17measured at 0.082 US Sv Feet RMSDz.

Approved by:	Name	Signature	Date
Associate Member, Lidar Specialist Certified Photogrammetrist #1381	Qian Xiao		September 2017

Section 6: Flight Logs

Flight logs for the project are shown on the following pages:

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	3/23/2017	82	77354		chippewa

Operator	Aircraft	HOBBS Start	Local Start Time	ZULU Start Time	Base
SMITH	N404CP	5927.2	1:19:00	17:19:00	
Pilot	**Sensor Type**	**HOBBS END**	**Local End Time**	**Zulu End Time**	**PID**
RADER	OTHER	5930.5	4:39:00	20:39:00	

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud	Departing	bjj
120/8	10			4	-10	3048		Arriving	bjj

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode		Threshold Values	
40	36	346	100	Gain - Course/Up		Single		A	
				Gain - Fine/Down		Multi	X	B	

Air Speed		AGL		MSL		Waveform Used				Waveform Mode		Pre-Trigger Dist.	
150	Kts	7800	Ft	8724	Ft	Yes		No		@	NS		Ft

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	HDOP	PDOP	Line Notes/Comments	
Test	n/a			n/a	n/a	n/a	n/a	GPS Began Logging At:	
↕ Times entered are Zulu / GMT ↕								Verify S-Turns Before Mission	Yes X No
25	n	17:35:00	17:37:00		19	0.6	1.2		
24	s	17:40:00	17:42:00		19	0.6	1.2		
23	n	17:45:00	17:48:00		17	0.6	1.3		
22	s	17:50:00	17:53:00		18	0.6	1.2		
21	n	17:55:00	17:59:00		19	0.6	1.1		
20	s	18:02:00	18:08:00		19	0.6	1.2		
19	n	18:10:00	18:17:00		19	0.6	1.2		
18	s	18:19:00	18:25:00		19	0.6	1.2		
17	n	18:27:00	18:34:00		19	0.6	1.2		
16	s	18:36:00	18:43:00		18	0.6	1.2		
15	n	18:45:00	18:51:00		19	0.6	1.2		
14	s	18:53:00	18:59:00		18	0.6	1.4		
13	n	19:02:00	19:07:00		17	0.6	1.4		
12	s	19:09:00	19:15:00		18	0.6	1.2		
11	n	19:17:00	19:22:00		17	0.6	1.2		
10	s	19:25:00	19:31:00		16	0.6	1.3		
9	n	19:33:00	19:38:00		16	0.6	1.3		
8	s	19:40:00	19:47:00		17	0.6	1.2		
7	n	19:49:00	19:55:00		15	0.6	1.6		
6	s	19:57:00	20:03:00		16	0.6	1.4		
5	n	20:05:00	20:10:00		16	0.6	1.5		
4	s	20:12:00	20:15:00		15	0.6	1.6		
3	n	20:17:00	20:19:00		15	0.6	1.6		
2	s	20:21:00	20:23:00		16	0.6	1.3		
1	n	20:25:00	20:26:00		17	0.6	1.3		
↑ Times entered are Zulu / GMT ↑				Page		1		Verify S-Turns After Mission	Yes X No

Additional Comments:	Drive #

Section 7: Final Deliverables

The final lidar deliverables are listed below.

- LAS v1.4 classified point cloud
- LAS v1.4 raw unclassified point cloud flight line strips.
- Hydro Breaklines as ESRI GDB
- Bridge Breaklines as ESRI GDB
- Digital Elevation Model in ERDAS .IMG format
- Digital Elevation Model in ArcGrid format
- 8-bit gray scale intensity images in .TIF format
- Tile layout provided as ESRI shapefile
- Control Points provided as ESRI shapefile
- FGDC compliant metadata per product in XML format
- Lidar processing report in pdf format
- Survey report in pdf format